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ABSTRACT

An experiment contrasted the predictions of two explanations of the cognitive review process of the post-passage adjunct question paradigm. The questions presented to 104 college students quizzed either information high in the organizational structure of the expository prose passage or information low in the structure. The top-down-search explanation predicted that the two question types would not differentially affect incidental recall because both types of questions would induce a top-to-bottom search for the information in the hierarchical passage representation, resulting in increased memory for information activated in the search. The direct-access explanation, however, predicted that the high-question condition would result in more indirect recall than would the low-question condition. This prediction was based on the assumptions that questions directly access the quizzed information in memory and that fewer associative links would have to be traversed in the spread of activation from high-level units to other related information in the hierarchy. The results supported the top-down search hypothesis. Incidental recall was facilitated equally in the high-question and low-question conditions relative to the no-question control condition. (Author/RL)

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Technical Report No. 241

POST-PASSAGE QUESTIONS: THE EFFECTS OF HIERARCHICAL IMPORTANCE

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Post-passage Questions:
The Effects of Hierarchical Importance

One of the conclusions generally drawn from reviews of adjunct question research is that questions requiring the production of specific isolated facts from the passage will have a facilitative effect on the retention of both quizzed and non-quizzed information when they appear after the segment of text containing the relevant fact (e.g., Anderson & Biddle, 1975; Rickards & Denner, 1978). This conclusion has been interpreted (e.g., Boyd, 1973; Frase, 1967; McGaw & Grotelueschen, 1972) as showing that post-passage questions induce a cognitive review of the passage which retards forgetting of both quizzed and non-quizzed information. Obviously, there are situations in which the effects of post-segment questions will not be limited to possible mental review processes. For example, repeated exposure to questions of a particular type interspersed throughout a prose passage will affect the processing of subsequent passage segments (Rothkopf, 1965; Rothkopf & Bisbicos, 1967). That is, post-segment questions can have both forward and backward effects. However, in the discussion to follow, attention will be focused on those situations in which forward effects are minimized by presenting all of the adjunct questions grouped at the end of the passage.

Despite its frequent use as an explanation of the backward effects of post-passage questions, the cognitive review process has never been specified in detail. However, developments in the study of prose passage structure effects on memory do provide one possible framework for

characterizing the review process. Recent work on text structure analysis (e.g., Frederiksen, 1972, 1975; Kintsch, 1974; Meyer, 1975, 1977) and story grammars (e.g., Mandler & Johnson, 1977; Rumelhart, 1975; Thorndyke, 1977; van Dijk & Kintsch, 1976) has shown that the hierarchical organization into which prose passage can be analyzed provides a basis for predicting the content and organization of a reader's recall of the material. All of the studies just cited have reported a direct, positive relationship between the recallibility of a passage proposition and its height in the hierarchical structure of the passage. Some investigators have also shown that high-level units are more resistant to forgetting than are low-level units (Kintsch, Kozminsky, Streby, McKoon, & Keenan, 1975; Meyer, 1975, 1977). Meyer and her associates (Meyer, Bartlett, Woods, & Rice, Note 1) have recently shown that the use of the passage's top-level organizational structure by the subject is highly correlated with the amount of material recalled. In examinations of story summarizations (Kintsch & van Dijk, 1975; Thorndyke, 1977), subjects have been shown to favor units most central to the organization of the passage while omitting low-level details. Frederiksen (1975) has also shown that the recall of passages tends to occur in chunks corresponding to structural units within the network, and McKoon (1977) has demonstrated a superiority for high-level units in a study of the delayed verification of passage propositions.

These findings of hierarchical organizational effects in memory for prose material suggest that a cognitive review process induced by post-passage questions might operate in a top-to-bottom fashion within the

memory representation of the passage. This top-down search hypothesis suggests that in answering an adjunct question the information sought is located in the process of tracing through the hierarchical structure from the highest to the lowest levels. Such a search would presumably proceed in parallel from the topmost unit to all of those units at the next level in the hierarchy. At that point, the search would be restricted to the topic cluster most likely to contain the relevant information. This focusing of the search process would be based on the amount of semantic overlap between the information in the question and the information in the codes for the various units at that level in the hierarchy. The search would continue in this fashion until the quizzed information is located. Thus, the indirect effects of post-passage questions would be the product of this top-to-bottom search. The specific mechanism by which the search process increases the retrievability of the units activated is open to question. The search process can be thought of either as increasing the memorability of the individual units activated, perhaps through the addition of contextual elements to their memory representation (e.g., Anderson & Bower, 1974; Jones, 1978), or as the strengthening and maintenance of associative connections traversed in the process of the search (e.g., Baddeley, 1976, pp. 95-99). Regardless of the specific mechanism involved, the top-down search hypothesis is one possible general characterization of the cognitive review process induced by adjunct questions.

An alternative explanation is based on the assumption that adjunct questions result in the direct accessing of the quizzed unit with a

subsequent spread of activation through the network. This notion of a spread of activation also assumes the hierarchical organization of the material and has often been used in theories of the organization of semantic memory (e.g., Collins & Quillian, 1969; Collins & Loftus, 1975). This notion of priming by means of a spread of activation has also been applied to explanations of general memory performance (Anderson, 1976; Anderson & Bower, 1973; McKoon & Ratcliff, 1979). On such a view, the activation spreads outward from the directly accessed unit to excite first those units most closely related to it in the associative network. Thus, the probability that a non-quizzed unit will be activated will be a function of its distance from the quizzed unit in the hierarchy. The result of this activation is assumed to be an increase in the memorability of the item, either through the maintenance of the associative links activated or through the addition of contextual retrieval cues to the activated units.

The experiment to be reported here attempted to distinguish between these two explanations of the cognitive review process by comparing the effects of high-level and low-level questions. Figure 1 shows for one of the passages used in this experiment the hierarchical representation resulting from the type of top-to-bottom parsing suggested by Meyer (1975, pp. 53-56). The main topics and their associated subtopics were classified as high-level units, and the details were classified as low-level units. The direct-access explanation would specifically predict a difference in the indirect effects (i.e. effects on non-quizzed information) of

high-level and low-level adjunct questions. This prediction is based on the fact that the number of pathways that would have to be traversed in the spread of activation from a quizzed low-level detail to other subtopic clusters within the same main topic would be greater than the number that would have to be traversed in the spread of activation from a quizzed high-level subtopic unit. Thus, the direct-access explanation would predict that high-level questions would produce greater facilitation of indirect recall from related subtopic clusters than would low-level questions.

Insert Figure 1 about here.

On the other hand, the top-down search hypothesis would predict an equal facilitation with high-level and low-level questions over the no-question condition with passages of the type employed in this experiment. For example, consider the following two questions derived from one of the subtopic clusters of the passage in Figure 1:

> High-level: One explanation of why birds migrate argues that a reduction in the supply of what forces the birds to migrate?
>
> Low-level: The major reduction in the supply of food for birds supposedly occurred when?

In the top-to-bottom search through the hierarchy, activation would first spread to the three main topics, at which point the main topic of "Why birds migrate" would be selected as the most likely candidate for the continuing search. Then, activation would spread in parallel to the subtopic units within that topic. At this point, a complete

match would be found between the high-level question and the subtopic unit, "One of these explanations of why birds migrate argues that a reduction in the supply of insects for food forces the birds to migrate," and the search would be terminated. In the case of the low-level question, a partial match with this subtopic unit would be detected, and the search would be restricted to the details within that subtopic cluster. The important point in regard to the indirect effects of the two question types is that the search process in both instances results in the same pattern of activation in units other than the subtopic cluster containing the directly quizzed information. This same pattern of activation should be reflected in an equal facilitation of indirect recall by high-level and low-level questions.

The two proposed explanations of the cognitive review process also make different predictions regarding high-level recall from the quizzed subtopic cluster. The direct-access explanation would predict that units directly quizzed by the question would be better recalled than units superordinate to a quizzed detail. The probability of a unit's being activated in such a way as to increase its memorability is expected on this view to be greater when the unit is directly activated by the question than when its activation is dependent on spread of activation from another directly accessed unit. On the other hand, the top-down search hypothesis would predict no difference in the recall of the two types of high-level units. This prediction is based on the assumption that the probability of activating the high-level unit in the quizzed subtopic does not vary as a function of which particular unit within the subtopic is quizzed.

The nature of the search process is invariant, and the high-level unit would be activated in answering either the high-level or the low-level question.

A measure of vocabulary ability was also included in this experiment in order to assess the generality of the findings. Recently, Curtis (1980) has presented evidence consistent with the position that verbal coding processes are slow in less skilled readers, thereby reducing the amount of attention available for other reading processes. One of these other reading processes likely to suffer in poor readers is the organization of the material in accordance with the important semantic relationships between elements in the material. Such a failure by verbally less skilled readers to organize material effectively in the absence of processing aids has been cited by Rickards and Denner (1978) as the basis for their showing a greater enhancement in performance with the use of higher-level post-questions than that shown by more skilled readers. In this regard, possible interactions of vocabulary ability and question condition were of interest in this experiment. For example, low-vocabulary subjects might be more likely to show a facilitative effect of the question conditions than high-vocabulary subjects would be. The relatively more impoverished organizational structure of low-vocabulary subjects would benefit more from question-induced activation than would the more well-established structure of high-vocabulary subjects.

Method

Subjects

A total of 104 students enrolled in psychology and English courses at Danville Area Community College participated in the experiment as part of a course requirement.

Materials

The materials read were three expository prose passages on the topics of bird migration, spiders, and color change in leaves. The spider passage was based on portions of an Audubon Society publication (Ashley, 1974). The bird migration passage was derived from a pamphlet of the Fish and Wildlife Service (USDI, 1971), and the leaf color change passage was based on portions of a National Forest Service brochure (USDA, 1967). The length of the passages in words was 611 for spiders, 724 for migration, and 722 for leaf color change. The passages were constructed so as to be highly hierarchically organized. Figure 1 shows the hierarchical organization of one of the passages resulting from the type of top-to-bottom parsing suggested by Meyer (1975, pp. 53-56). Each passage contained information about three main topics. For the purpose of this experiment, the sentences specifying the topics to be discussed and the sentences specifying the subtopics within each of the three main topics were considered high-level information. All sentences containing detail information about the subtopics was designated as low-level information. Within each passage, one of the main topics contained four subtopics, one contained three subtopics, and the other contained two subtopics. One of the passages used is

presented in Appendix A. The other materials can be obtained from the author on request.

The questions employed in the study were generated by replacing segments of sentences presented in the passages with interrogatory terms. Nine high-level questions were derived for each passage by converting each sentence announcing a subtopic into a question. Nine low-level questions were formed by converting one detail sentence from each subtopic into a question. The detail sentences selected for conversion to questions were chosen on the basis of which detail sentence within each subtopic could most unambiguously be presented as a question. Examples of questions are also shown in Appendix A. Each high-level question contained explicit reference to one of the main topics in the passage and required as a response one of the subtopics, while each low-level question contained explicit reference to one of the subtopics and required detailed information as a response. For example, for the subtopic cluster reading:

> One of these explanations of why birds migrate argues that a reduction in the supply of insects for food forces the birds to migrate. This reduction in the food supply is caused by the cold winter weather in the north. The first major reduction in the supply of food for birds supposedly occurred when glaciers advanced into the northern part of North America during the ice age.

the high-level question was: "One explanation of why birds migrate argues that a reduction in the supply of what forces the birds to migrate?"; and the low-level question was: "The first major reduction in the supply of food for birds supposedly occurred when?"

Design and Procedure

Each subject received two questions, one high-level and one low-level, about each of the three passages read. The questions quizzed information from two of the three main topics in the passage. The pairing of questions was counterbalanced across subjects such that each possible high-level question from one passage appeared equally often in conjunction with each possible low-level question from the other two main segments of the passage. The order of the passages was randomized for each subject.

Subjects were tested in groups ranging in size from eight to 25 during regularly scheduled class meetings. The subjects were instructed in writing and orally by the experimenter to read each passage so as to be able to answer questions about main ideas and questions about details when they appeared after each passage. Subjects were allowed to read the passages at their own speed, but they were encouraged not to spend a lot of time on any one of the passages. The passages were presented in booklet format. Immediately after each passage a long division arithmetic problem was presented in the booklet for subjects to work. The problem was included in order to reduce the probability that subjects would be able to answer the presented questions on the basis of the maintenance of the information in short-term memory store. The two questions were presented on the page immediately following the arithmetic problem, and the subjects wrote their answers under the questions. The subjects were not allowed to refer back to the passage when answering the questions. Following the questions for the first passage, the subjects proceeded to read the second and third passages following the same procedure as for the first passage.

After completing the questions for the third passage, subjects waited until all members of the group finished the three passages.

A series of intervening booklet tasks was then administered. Subjects first completed one half of the Wide Range Vocabulary Test (French, Ekstrom, & Price, 1963), consisting of 24 multiple-choice items. This was followed by a nine-item biographical questionnaire requiring short answers. Finally, subjects completed a questionnaire consisting of the extraversion and lie-scale questions from the Eysenck Personality Questionnaire (Eysenck & Eysenck, 1975). The vocabulary test was timed, but the other two tasks were unpaced. Preliminary analyses indicated that the extraversion measure did not interact significantly with any of the within-subject factors. Thus, the extraversion measure will not be discussed further.

Prior to completing the biographical and personality questionnaires, subjects were given both written and oral instructions for the unexpected free recall task. Subjects were asked to recall the three passages under the titles presented on the last pages of the booklet. The titles were presented in the order in which the passages were read, and subjects were asked to recall the passages in the order in which the titles were presented, after completing the questionnaires. Subjects were urged to recall the passages in a form as similar to the original as possible, but they were told to recall information in their own words when unable to remember the original wording. The importance of making all recall in the form of complete sentences was stressed to the subjects. Subjects were not allowed to refer back to the passages during recall. The recall task was unpaced,

but no subject spent more than 45 minutes in completing the questionnaire and recall tasks.

The free recall protocols were scored using a method similar to that employed by Rickards and his associates (Rickards & August, 1975; Rickards & DiVesta, 1974). Each test sentence was reduced to its essential proposition or propositions, and each recalled sentence was judged on the basis of whether it captured the gist of one of these propositions. A rating of 2 was used to indicate that the match between text proposition and recalled sentence was totally acceptable, and a rating of 1 was used to indicate that the match was only partial. The objectivity of this scoring procedure was determined by having a graduate student as well as the experimenter score all protocols. The Pearson product moment correlation between the two raters' scores was .93. Both raters scored the protocols without knowledge of which text segments had been quizzed. Answers to the adjunct questions were scored according to a gist criterion by both the experimenter and the graduate student assistant. The decisions of the two raters were in agreement for 95% of the answers. The scoring of the problematic answers was arrived at by means of conference between the experimenter and the graduate assistant.

Results

In the three analyses to be reported below, a between-subject factor of vocabulary ability was employed. Subjects were divided into high-vocabulary and low-vocabulary groups on the basis of their scores on the Wide Range Vocabulary Test (French, Ekstrom, & Price, 1963). A subject's

score on the test equalled the number of the 24 multiple-choice questions answered correctly minus one-fifth of the number answered incorrectly. The high-vocabulary group consisted of the 52 subjects scoring above the median vocabulary score of 6.2, while the low-vocabulary group consisted of the 52 subjects scoring below the median.

Question Answering.

For each subject, the number of high-level and low-level questions answered correctly was determined. The data were submitted to a split-plot analysis of variance with question type (high-level vs. low-level) as the within-subject factor. The means from this analysis are shown in Table 1. The factor of vocabulary group was significant, $F(1,102) = 7.58$, $p < .01$, $MS_e = 1.52$. High-vocabulary subjects answered more questions correctly than did low-vocabulary subjects. Neither the factor of question type, $F(1,102) < 1$, $MS_e = .48$, nor the interaction of question type and vocabulary group, $F(1,102) < 1$, $MS_e = .48$, was significant.

Insert Table 1 about here.

Overall Indirect Recall

In the overall analysis of the indirect recall results, two within-subject factors of recall level (high vs. low) and question (high, low, and no) were employed. On the basis of the scorers' coded analysis of each subject's recall, a determination was made as to whether there was any indirect high- or low-level recall from each of the three major segments

of each passage. As described above, each segment represented one of the three question conditions. In the case of the passage segments from which the two presented questions were drawn, indirect recall consisted of information recalled from a subtopic cluster that was not directly quizzed and information recalled from the superordinate proposition that introduced the main topic within which the quizzed subtopic was discussed. For the segment for which no question was presented, all information in the segment qualified to be counted as indirect recall. Thus, for each subject, the number of passages from which there was recall in each of the six conditions (2 levels of recall x 3 question conditions) was determined, and these data were submitted to a split-plot analysis of variance.

The means from this analysis are shown in Table 2. The effect of vocabulary group was significant, $F(1,102) = 13.29$, $p < .001$, $MS_e = 2.20$, with high-vocabulary subjects outperforming low-vocabulary subjects. The factor of recall level was also significant, $F(1,102) = 49.03$, $p < .001$, $MS_e = .42$, with subjects showing more high-level indirect recall than low-level indirect recall. The interaction of recall level and vocabulary group was not significant, $F(1,102) < 1$, $MS_e = .42$.

Insert Table 2 about here.

Neither the factor of question, $F(2,204) < 1$, $MS_e = .85$, nor the interaction of question and vocabulary group, $F(2,204) = 1.09$, $MS_e = .85$, was significant. However, the interaction of recall level and question was significant, $F(2,204) = 7.93$, $p < .001$, $MS_e = .38$. Tests of simple

main effects showed that the question conditions differed significantly in the case of high-level recall, $F(2,204) = 4.87$, $p < .01$, $MS_e = .62$, but not in the case of low-level recall, $F(2,204) = 1.02$, $MS_e = .62$. For high-level recall, Tukey's test revealed that recall in both the high-question condition and the low-question condition significantly exceeded recall in the no-question condition. The high-question condition and the low-question condition did not differ significantly.

The analysis also revealed a significant triple interaction of recall level, question, and vocabulary group, $F(2,204) = 3.49$, $p < .04$, $MS_e = .38$. Tests of simple interactive effects showed that the effect of question was significant for low-vocabulary subjects in the case of high-level recall, $F(2,204) = 7.87$, $p < .01$, $MS_e = .62$, but not in the case of low-level recall, $F(2,204) < 1$, $MS_e = .62$. By Tukey's test, high-level recall in both the high-question condition and the low-question condition significantly exceeded high-level recall in the no-question condition. The high-question and low-question conditions did not differ significantly. For high-vocabulary subjects, the effect of question was not significant for either high-level or low-level recall, both with $F(2,204) < 1$, $MS_e = .62$.

Recall from the Quizzed Subtopic

The final set of analyses concerned high-level recall from the quizzed subtopic cluster. The frequency of recall of three types of high-level subtopic sentences was compared. The three types of subtopic sentences compared were directly quizzed subtopic sentences, subtopic sentences superordinate to a directly quizzed detail, and subtopic sentences from

topic clusters not quizzed by a question. The control subtopic sentence from the non-quizzed topic cluster of each passage was randomly selected for each subject. These data were also submitted to a split-plot analysis of variance. The means from this analysis are shown in Table 3. The between-subject factor of vocabulary group was significant, $F(1,102) = 9.33$, $p < .003$, $MS_e = 1.20$, with more recall by high-vocabulary subjects than by low-vocabulary subjects. The factor of recall type was also significant, $F(2,204) = 5.15$, $p < .007$, $MS_e = .70$. Tukey's test showed that both recall of directly quizzed subtopic sentences and recall of subtopic sentences superordinate to a directly quizzed detail significantly exceeded recall of the control subtopic sentence. There was no significant difference in the recall of directly quizzed subtopic sentences and subtopic sentences superordinate to a directly quizzed detail. The interaction of recall type and vocabulary group was not significant, $F(2,204) < 1$, $MS_e = .70$. The means in Table 2 and Table 3 are not directly comparable because in the analysis of recall from the quizzed subtopic each condition was represented by one specific sentence in each passage, whereas in the analysis of overall indirect recall each condition was represented by more than one specific sentence in each passage, and thus there were more opportunities for indirect recall.

Insert Table 3 about here.

Discussion

The results reported here favor the top-down search explanation of post-passage question effects over the direct-access explanation.

High-level and low-level questions facilitated high-level indirect recall to an equal degree in relation to the no-question control condition. In addition, the recall of high-level units superordinate to a quizzed detail and the recall of directly quizzed high-level units were facilitated to an equal degree over recall of high-level units from the control segment. These findings are consistent with the suggestion that in answering questions the quizzed information is located as a result of a top-down search of the hierarchical memory structure constructed at the time of reading the passage. Neither of these patterns of results would be predicted by the direct-access explanation. In the case of overall indirect recall, the direct-access explanation predicted the high-question condition to be superior to the low-question condition because of the smaller number of pathways that would have to be traversed in the spread of activation from a quizzed high-level unit to other units in the same topic cluster. In addition, the direct-access explanation predicted, contrary to the results found, that high-level units directly quizzed would be better recalled than high-level units which were superordinate to quizzed details and thus, on this view, only indirectly activated by the spread of activation from the directly accessed quizzed details.

The results of the analysis of the question answering data support this interpretaion of the free recall results. First of all, the means presented in Table 1 show that subjects on average answered over half of the questions correctly. Thus, the subjects did tend to be successful in accessing the information required by the questions. This finding supports the top-down

search explanation of the free-recall facilitation over an alternative explanation in terms of the information provided in the question stem. In addition, the equal facilitation in the high-question and low-question conditions argues against the possibility that the free-recall facilitation was due solely to information provided in the question stem. Given that the high-question contained explicit reference to the main topic or main organizational idea of the passage segment whereas the low question did not, free-recall facilitation should have been greater in the high-question condition than in the low-question condition if the facilitation were due solely to the information provided in the question stem. Finally, the finding that low questions were answered as well as high questions is also consistent with the proposed top-down search explanation. When the top-down search is equally successful in the two question conditions, the recall facilitation in the two conditions would be expected to be equal.

The interaction of recall level, question, and vocabulary group in this experiment supports the notion that processing aids such as questions are more likely to benefit the performance of lower-ability subjects than of higher-ability subjects (Rickards & Denner, 1978). To the extent that lower-ability subjects are less efficient at effectively establishing in memory the organizational structure of the passage (Curtis, 1980), they would tend to benefit more from activation of the structure in response to questions. The differential effectiveness of the question manipulation for lower-ability subjects may also reflect their tendency to fail to use spontaneously the organizational structure of the passage (Meyer, 1979; Meyer, Brandt, & Bluth, 1980).

One unanticipated feature of the results was the finding that the effect of the question manipulation was significant for high-level recall only. In general, an increase in the retrievability of high-level units would be expected to increase the retrievability of associated low-level information. Of course, with a free recall task, there is always the possibility that information was available in memory that was not accessed and recalled. Britton, Meyer, Hodge, and Glynn (1980) have pointed out that a subject's response criterion can influence the magnitude of the difference in the recall of high-level and low-level passage information. Specifically, Britton et al. suggest that time limitations on free recall may lead subjects to impose a criterion based on importance which will favor the recall of high-level over low-level information. The authors further suggest that the more discriminable the high-level and low-level information is, the greater the effect of response criteria is likely to be. Both of these conditions may have obtained in the experiment reported here and contributed to the interaction of question condition and recall level. Although there was no experimenter-imposed time limit on subjects' free recall of the passages and subjects were encouraged to take as much time as needed to complete their recalls, many of the subjects had obligations in the form of other classes which prevented them from continuing with the task beyond the scheduled one-and-a-half hour class period. In addition, on the basis of the kind of retrieval operations which have been suggested to operate in the question conditions of this experiment, it is reasonable to assume that the discriminability of high-level and

low-level information was greater in the passage segments quizzed by a question than in the no-question control segment. This assumption is based on the prediction that the search process through the two-quizzed segments results in the differential activation of the high-level information in these segments. That is, activation of high-level units in the process of answering a question would increase their memorability relative to high-level units from the non-quizzed segment, and this activation would also increase their perceived importance relative to their subordinate details. Thus, the superior retrievability of high-level units from quizzed passage segments might not be reflected in the superior recall of their associated details because the time-motivated response criterion would focus the recall effort on the more prominently represented high-level units.

Thus far the direct-access explanation and the top-down search hypothesis have been treated as mutually exclusive and independent hypotheses. However, even though the results presented here have been interpreted as supporting the top-down search process, it is not reasonable to conclude that questions never result in the direct accessing of encoded information. In fact, both processes are likely to be involved in certain question-answering situations. In particular, if one assumes a retrieval model of the type proposed by Mandler and his associates (e.g., Mandler, 1972, 1977; Mandler Pearlstone, & Koopmans, 1969; Rabinowitz, Mandler, & Barsalou, 1977; Rabinowitz, Mandler & Patterson, 1977), then direct accessing of information must be considered likely to occur when the question is

presented in close temporal proximity to the passage segment containing the quizzed information. The Mandler model stipulates that information is represented in both a perceptual code and a conceptual code. The perceptual code corresponds to the superficial, non-semantic characteristics of the information while the conceptual code corresponds to the semantic representation of the information. The Mandler group argues that the perceptual code permits direct accessing of encoded information but that this code is short-lived. Once the perceptual code is no longer available, retrieval of information is based on the conceptual code, and retrieval via the conceptual code can involve a search through a hierarchical network, depending on the organization of the material studied. It was just this type of hierarchical search that the top-down search hypothesis proposed in accounting for the indirect retention effects of retrieving information in response to delayed questions.

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Appendix A

Bird Migration

The migration of North American birds refers to the regular flights between their summer homes in the north and their winter homes in the south. Except for those that nest in the tropics, nearly all North American birds migrate, some great distances while others go only a short way. In the study of migration, answers to the questions why do birds migrate, how do birds navigate on their migrations, and what dangers do birds encounter during migration are of particular interest.

To the question of why birds migrate, three explanations have been proposed. One of these explanations of why birds migrate argues that a reduction in the supply of insects for food forces the birds to migrate. This reduction in the food supply is caused by the cold winter weather in the north. The first such major reduction in the supply of food for birds supposedly occurred when glaciers advanced into the northern part of North America during the ice age. Another popular explanation of why birds migrate is that birds receive at birth an imprint, or lasting impression, of their birth place. This imprinting results in a lifelong urge to return to that locale each spring. Many theorists believe that the imprint of the birth place occurs within twenty-four hours after hatching. A final interesting explanation of why birds migrate is that a change in the length of

day prepares birds for their migration by altering their breeding condition. A decrease in the length of day decreases a bird's sexual arousal and results in migration to the winter home, while an increase in the length of day increases a bird's sexual arousal and causes it to seek its nesting grounds in the north. A change in the length of day apparently alters the level of hormones in the bloodstream of birds.

Several possible answers to the question of how birds navigate on their migrations have also been suggested. The earliest explanation of how birds navigate was that birds possess a built-in compass which guides them to their destination. According to this view, such a built-in compass makes landmarks and cues in the environment unnecessary for successful completion of the trip. Evidence for the existence of this built-in compass has not been confirmed by modern day animal scientists. Another frequently cited explanation of how birds navigate suggests that birds use the sun and the stars as reference points in their migrations. This reliance on the sun and stars may account for the ability of some birds to cross vast stretches of ocean. Variations in the density of clouds is likely to affect most those birds using the sun and stars. Another factor which has been presented as contributing to the ability of birds to migrate across land is their search for previously encountered landmarks to guide them. It is suggested that the ability to make use of landmarks is

the result of a learning process, with veteran flyers somehow teaching young birds the path to follow. Laboratory studies of birds' use of landmarks have demonstrated that birds can detect even slight variations in the appearance of boundary markers in areas over which they have flown before. A recent explanation which has been proposed by some researchers to account for the ability of birds to navigate is that birds navigate by detecting slight differences in the magnetic field of the earth. This ability to detect such differences in magnetic field is assumed to be the product of the bird's use of inborn receptors for differences in field strength. Even young birds who lack adult guidance and experience in actual migration may be sensitive to magnetic field differences.

In response to the question of what dangers migrating birds face, researchers typically cite two major threats, one man-made and one natural. The major man-made danger to migrating birds is that of aerial obstacles. Aerial obstructions such as television towers and monuments are responsible for the deaths of thousands of migrating birds each year. Fog and low cloud cover are the two factors which contribute most to the tendency of lighted aerial obstacles to attract birds at night. The natural danger which most affects migrating birds is storms. Storms such as inland hailstorms kill great numbers of small birds. The lack of dense vegetation in vast areas over which the birds fly prevents them from seeking shelter from storms.

Example Questions

High-level: One explanation of why birds migrate argues that a reduction in the supply of what forces the birds to migrate?

The earliest explanation of how birds navigate was that birds possess a built-in what?

The major man-made danger to migrating birds is what?

Low-level: The first major reduction in the supply of food for birds supposedly occurred when?

Evidence for the existence of a built-in compass has not been confirmed by whom?

What are the two factors which contribute most to the tendency of lighted aerial obstacles to attract birds at night?

Table 1

Mean Number of Questions Answered Correctly

Vocabulary Group	Question Type	
	High	Low
High	2.02	1.98
	(0.78)	(1.04)
Low	1.54	1.52
	(1.02)	(1.13)
Combined	1.78	1.75

Note. The maximum possible total score was 3.00. The numbers in parentheses are the standard deviations.

Table 2

Mean Number of Overall Indirect Recalls

Vocabulary Group	Question Condition		
	High	Low	No
High Level Recall			
High	2.06	1.98	1.96
	(0.85)	(0.83)	(0.86)
Low	1.65	1.77	1.19
	(0.93)	(0.96)	(0.95)
Combined	1.86	1.88	1.58
Low Level Recall			
High	1.50	1.63	1.69
	(0.92)	(0.86)	(1.00)
Low	1.17	1.15	1.29
	(0.92)	(1.00)	(0.94)
Combined	1.34	1.39	1.49

Note. The maximum possible total score was 3.00. The numbers in parentheses are the standard deviations.

Table 3

Mean Number of Recalls from the Quizzed Subtopic

Vocabulary Group	Recall Type		
	Units Directly Quizzed	Units Superordinate to Quizzed Details	Control Units
High	1.44	1.52	1.19
	(0.89)	(0.96)	(0.97)
Low	1.15	1.10	0.77
	(0.92)	(1.01)	(0.81)
Combined	1.30	1.31	0.98

Note. The maximum possible total score was 3.00. The numbers in parentheses are the standard deviations.

Figure Caption

Figure 1. The hierarchical representation of one of the three passages read.